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The Journal of HEREDITY

A monthly publication devoted to Plant Breeding Animal Breeding and Eugenics

JUNE, 1924

THE CRANBERRYBUSH
George Darrow

INHERITANCE OF "BOLTING"
E. P. F. Sutton

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W. A. Craft and H. W. Orr

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"MINIATURE GERM" IN MAIZE
John B. Wenz

SELECTING FARM ANIMALS
B. M. Gonzalez

PUBLISHED BY THE
AMERICAN·GENETIC·ASSOCIATION
BALTIMORE, MD. AND WASHINGTON, D.C.

Volume XV Number 6

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The

Journal of Heredity

VOL. XV, NO. 6 JUNE, 1924

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The JOURNAL OF HEREDITY is published monthly by the

AMERICAN GENETIC ASSOCIATION

At 1918-32 Harford Avenue, Baltimore, Md., and
Victor Building, Washington, D. C.

Address communications regarding editorial matters and the business management of the Association to Room 306, Victor Building, Washington, D. C.

Entered as second class matter February 24, 1923, at the post office at Baltimore, Maryland. Acceptance for mailing at the special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized December 20, 1918. Contents copyrighted 1924 by the American Genetic Association. Reproduction of articles or parts of articles permitted only upon request, for a proper purpose, and provided due credit is given to author and to the JOURNAL OF HEREDITY, Washington, D. C.

Date of Issue of This Number, August 21, 1924

$3.50 a Year, 35c the Copy

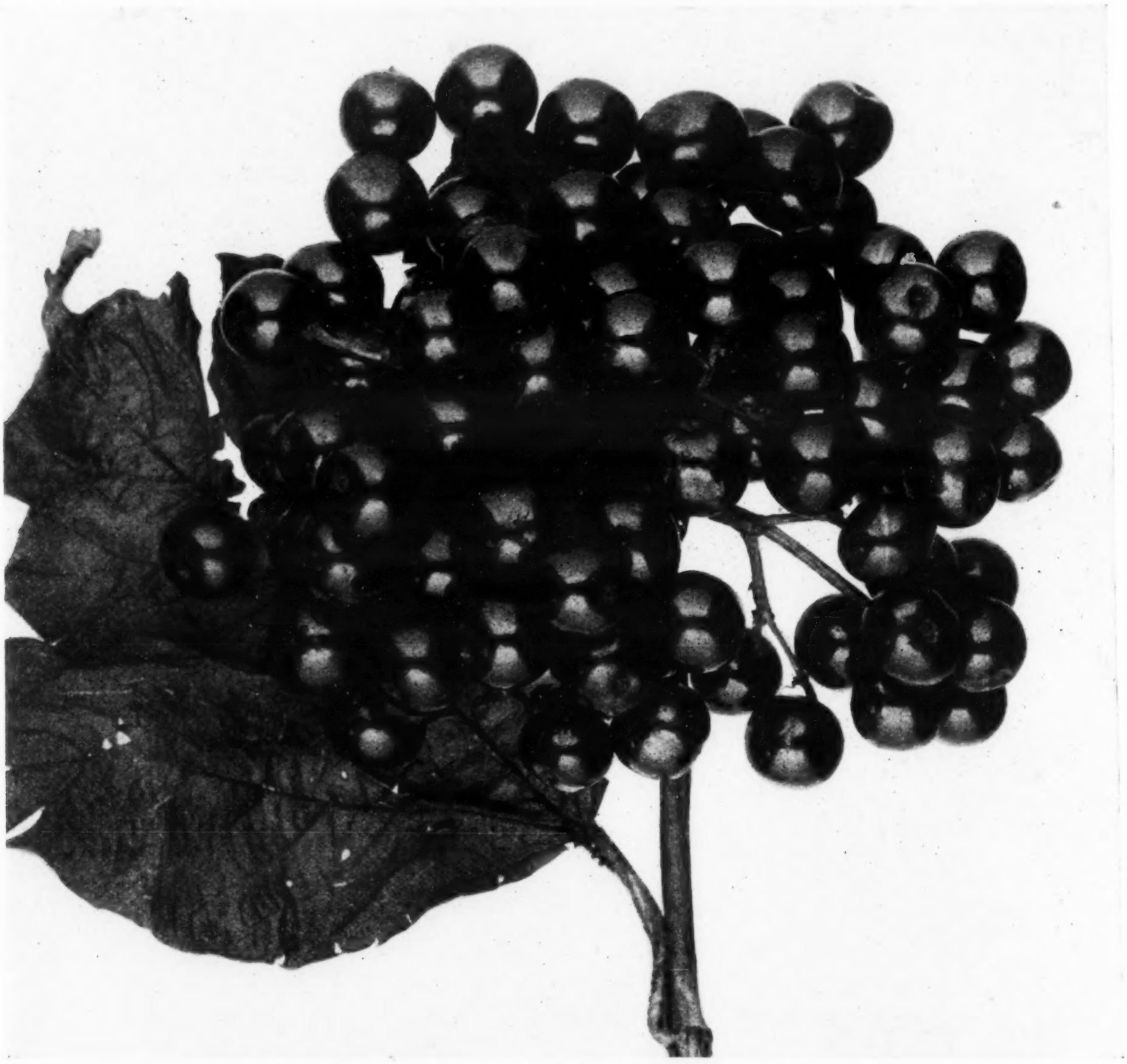
THE CRANBERRYBUSH AS AN ORNAMENTAL

The cranberrybush bears red berries somewhat like cranberries, which no doubt explains the origin of the name. In spite of this resemblance, the plants are not otherwise alike, the cranberrybush being a near relative of the elderberry. Other species of Viburnum have long been used as ornamentals, but selections of the native American Viburnum are fully as showy as any of these. None of the other ornamental Viburnums have edible fruits, and an attempt is being made to replace them with the native "dual purpose" species. (Frontispiece.)

THE AMERICAN CRANBERRYBUSH

The Domestication of Viburnum Americanum—A New Fruit for the Northern United States

GEORGE M. DARROW
U. S. Department of Agriculture



FRUIT OF THE AMERICAN VIBURNUM

FIGURE 1. The clusters of fruit may be large or small, loose or compact, erect or drooping, with berries globose or elongated, light or dark red or yellow-banded, early maturing or late, depending on the characteristics of the individual plants, and to some extent on the environmental conditions.

IN SECTIONS of the northern United States and in Canada, settlers for many years have used a native wild fruit, the *pembina** as the Indians called it, which furnishes them jelly as rich in color and in pectin as that made from cranberries and currants. Another name is often given

*The name "pembina" has been officially adopted by the Great Plains section of the American Society for Horticultural Science.

FRUIT BORNE IN DROOPING CLUSTERS

FIGURE 2. The brilliant red fruit clusters may be pendant as these are, borne on stiff stems, as those shown in Figure 5. The great range of variation found in individual plants offers a fine chance for improvement by hybridization and selection. Superior plants can be propagated by cuttings or layering. (See Figure 7.)

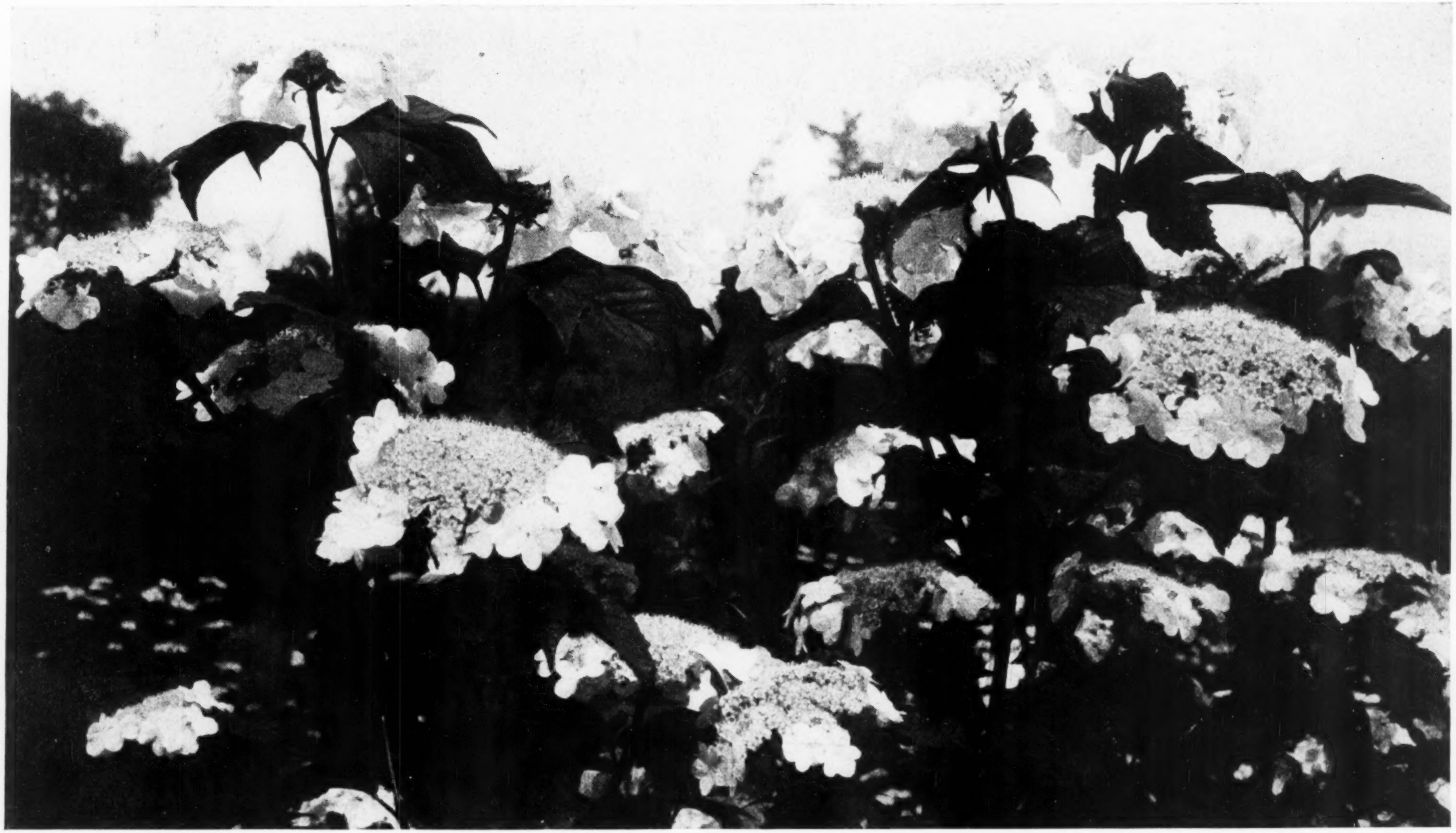
it, the *high bush cranberry* or *American cranberrybush*,† because the fruit resembles the cranberry, although it is borne on a high bush and in clusters like the elderberry.

This American cranberrybush, botanically known as *Viburnum americanum*, is a close relative of the elderberry and grows to about the same height and in similar clumps. It is often confused with the European *Viburnum opulus* which is widely used in this country as an ornamental, but is distinguished from the latter most readily by its clear acid fruit while that of *V. opulus* is so intensely bitter as to be inedible.

†"American cranberrybush" has been adopted as the recognized name of this plant in *Standardized Plant Names*.

A WILD PLANT IN NEW HAMPSHIRE

FIGURE 3. The upper picture shows a large bush of *V. americanum* growing in a meadow on the side of Mt. Prospect, near Lancaster, N. H. Below is shown a fruiting branch of the same bush. The Indians ate this fruit, which they called *pembina,* and for many years it has been used in a small way by settlers in the Northern States and Canada.



FLOWER CLUSTERS OF AMERICAN VIBURNUM

FIGURE 4. Actual counts show that only from five to ten per cent of the flowers ripen fruit.

FRUIT CLUSTERS BORNE ON ERECT STEMS

FIGURE 5. Compare the habit of growth of this plant with the drooping clusters of fruit shown in Figures 2 and 3.

V. americanum

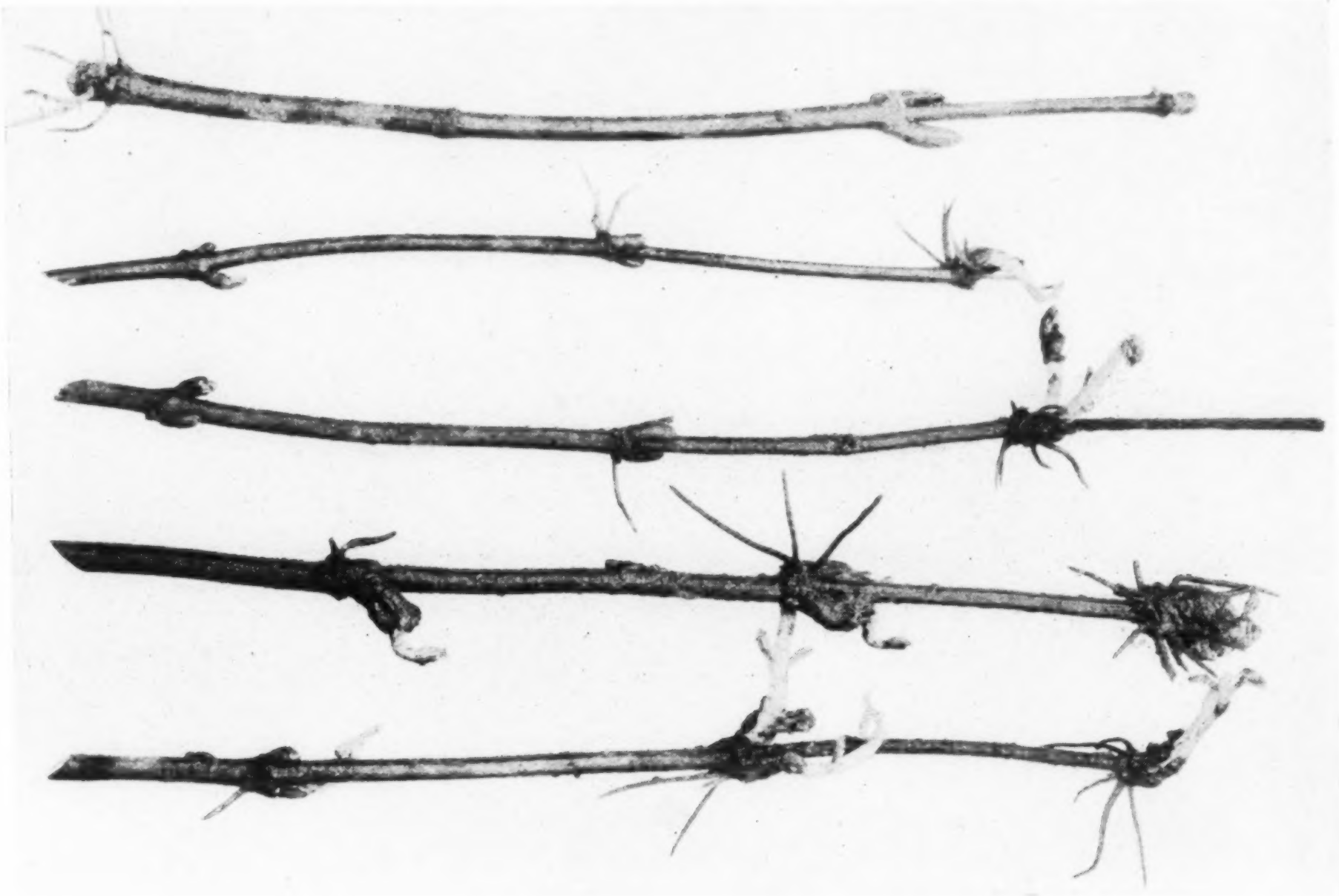
V. lentago

V. lantana

V. opulus

FRUITS OF ORNAMENTAL SPECIES OF VIBURNUM

FIGURE 6. *Opulus*, a bitter-fruited European species, is widely grown as an ornamental, being known as the "Snowball bush." It has long been known that the fruits of the American species were edible, and plantings have been made to utilize these, but it is certain that in some cases, at least, the bitter-fruited *opulus* was planted instead.



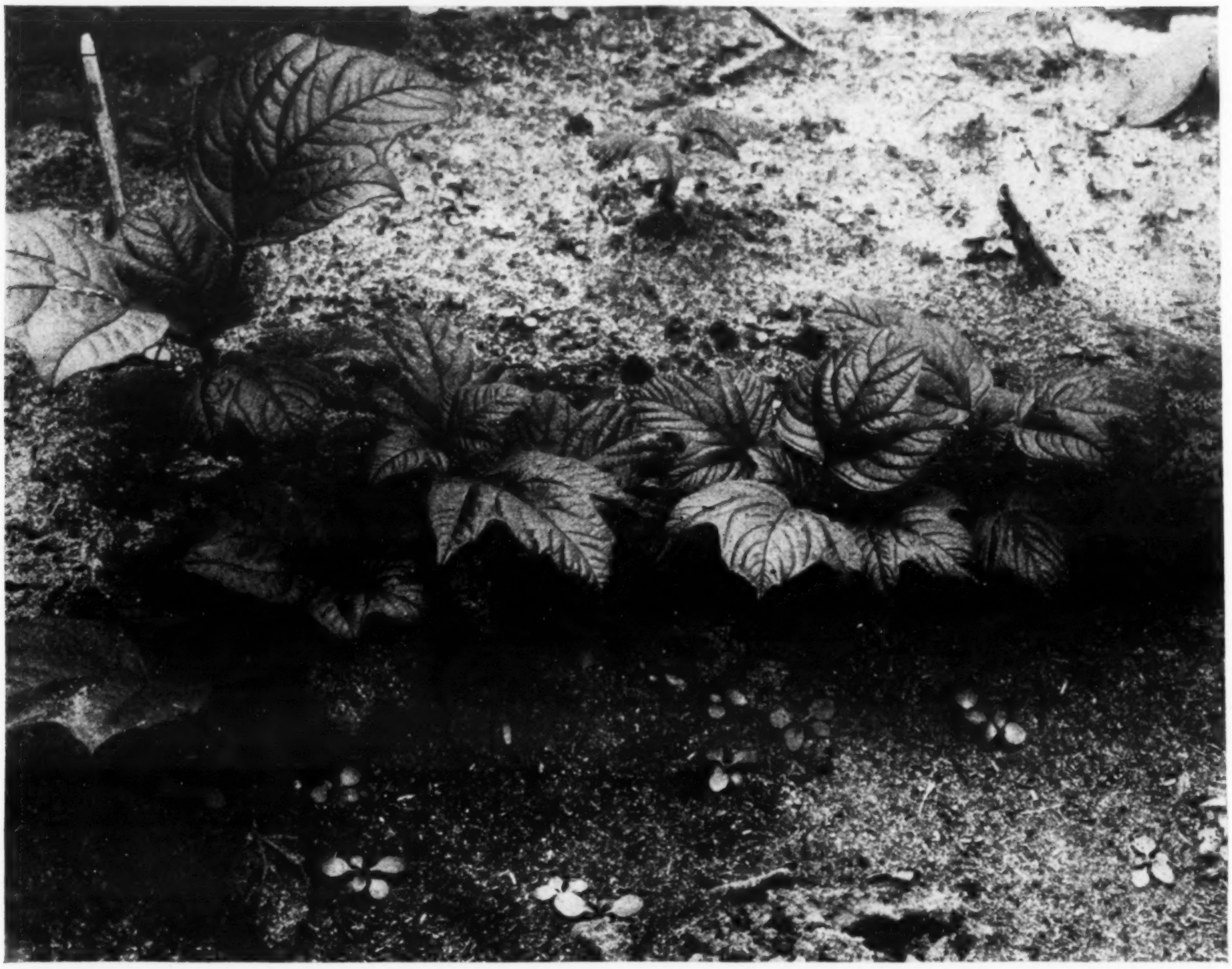
PROPAGATING THE CRANBERRYBUSH

FIGURE 7. A new method has been devised for propagating Viburnum. Cuttings are buried in a horizontal position, and shortly callous material pushes out from the center of the buds, and roots start from their base. Shoots soon develop as shown here, and with roots attached they can be separated from the old cane. The usual methods of propagation are by hardwood cuttings, similar to those shown, placed in an upright position; by softwood cuttings in summer; and by layering.

Several times in the past attempts have been made to introduce *V. americanum* as a garden fruit, but it is evident, in some cases, at least, the bitter fruited *V. opulus* was sold instead. The last attempt was between forty and fifty years ago. Some plantings made then are still in existence and are of the bitter-fruited *V. opulus*.

In Minnesota and North Dakota, fruit of the American cranberrybush is sometimes sold in the local markets, and occasionally in those of northern New York and New England. In sections of Manitoba and Saskatchewan in Canada it is highly prized, and is the principal wild fruit. It is there gathered and sold locally every year in large quantities, seldom bringing a lower price than $3 per bushel on the stems. In a few places in Maine, New Hampshire, New York, Iowa, and North Dakota, bushes from the wild have been transplanted to farmyards and gardens, but no systematic attempt, so far as is known, has ever been made to select and develop varieties for the market until that reported here. In northern New Jersey, however, one plantation was established to raise *Viburnum americanum* for its bark, which yields a valuable drug.

Mr. A. E. Morgan, of Dayton, Ohio, in the course of his engineering work, became interested in this fruit and undertook its improvement. His first step was to secure fruit from Alaska to Newfoundland to study its variation. Next he made a personal survey of sections of northern New York and New England. As a result of this survey he established a plantation in the Berkshire Mountains near East Lee, Massachusetts, where selections



ROOTED CUTTINGS OF VIBURNUM

FIGURE 8. These plants were propagated by rooting hardwood cuttings similar to those shown in Figure 7, and were photographed at the end of the first season's growth.

of the best wild bushes were planted in the autumn of 1915 and 1917. Many of these were large bushes which were divided to form several plants. Cuttings were taken from the more desirable bushes to propagate a larger stock of plants. Seeds of many of the most desirable were planted in order to raise a stock of seedlings from selected bushes to make further selections.

In 1919 and 1920, Mr. Morgan distributed about 3300 plants from his East Lee plantation to cooperating experiment stations in the northern United States from Maine, westward to Idaho. This number included plants grown from seeds and from cuttings and some divisions of the best of the bushes transplanted from the wild.

Mr. Morgan later became president of Antioch College in Ohio, and as it was impossible for him to give the plantation his personal attention, he offered to turn it over to the United States Department of Agriculture. This was done in the spring of 1921. Since that time the plantation has been under the direction of the Bureau of Plant Industry. Additional nursery stock has been sent to cooperating experiment stations and the plantation at East Lee, Massachusetts, is being brought into full fruiting as soon as possible.

Some bushes bore considerable fruit in 1922 and three superior plants were selected for propagation. Tests of the fruit for jelly have shown it to be rich in pectin and acid and to make a jelly in color and consistency fully equal to that from the currant. Jelly of the finest color and consistency was made

YOUNG SEEDLING PLANTS

FIGURE 9. These plants were photographed in August of their second year's growth from seed. Great diversity is found in such seedlings, and superior plants can be propagated by cuttings or layering. (See Figure 7.)

SOME BUSHES HOLD THEIR FRUIT FOR SEVERAL MONTHS

FIGURE 10. This young bush of American Viburnum is still laden with clusters of bright red berries in the middle of November.

as early as August 19 from certain varieties, and again as late as the middle of November from fruit still hanging on the bushes. The jelly has a characteristic flavor so highly prized by some that they consider it equal or superior to any other, while others do not care for the flavor.

Because of the hardiness of the bush, its decorative value, and the amount, color and consistency of the jelly, selections of the best varieties are being made and propagated for later distribution. It is likely to reach its greatest value in those sections to which it is native or where the winters are so cold that there are relatively few other fruits. Its hardiness in northern Wisconsin and throughout Minnesota and North Dakota, where only the hardiest fruits are grown, suggests its particular value for such regions. Throughout the whole of the northern United States the cranberrybush deserves to be grown by those who are interested in it as a dooryard ornamental, who like a variety of fruits for jellies, marmalades, and fresh fruit drinks, or who prize its characteristic flavor.

In regions where the currant and gooseberry cannot be grown because of the menace of the white pine blister rust, the *pembina* should be a particularly valuable addition to the garden.

To minimize the danger of a substitution of the bitter-fruited European *V. opulus*, an attempt is being made to replace the latter in the trade with *V. americanum*, by furnishing seed for a period of several years to nurserymen who raise plants for ornamental purposes. Landscape gardeners consider the American form preferable as an ornamental because it is more resistant to aphids and makes a better growth. Furthermore, selections of several varieties for their ornamental value have been made and are being propagated as rapidly as possible. These are much more ornamental than most seedlings of the species and are preferable to seedlings of the bitter European Viburnum.

Botany for Beginners

GENERAL BOTANY, BY EDGAR NELSON TRANSEAU, Professor of Botany, The Ohio State University. Pp. x + 560. The World Book Company, New York. 1923.

The aim in adding this general botany text to the many already published is to make available to teachers an arrangement of material which has been found exceptionally suitable for large classes of beginning students. With the ever increasing number of students who pursue the study of botany for one year only, there has arisen a need for a course which presents the general aspects of the subject in an interesting manner. This need has been met by Dr. Transeau's new book. The fact that the contents of the book have been used in large classes for several years proves its practicability and its appearance in print gives others an opportunity to share its usefulness. The book is well planned and very well balanced for a general text which purports to give a broad view of the subject. The material is presented in an easy reading style in such a way as to arouse questions in the beginner's mind. It is intended that the student will answer such questions largely by examining actual material in the laboratory or field. In this way the student has an opportunity to become acquainted with the elementary aspects of botany without being burdened with needless details.

The author has appropriately chosen to open the volume with a consideration of the many uses made of plant products and the need for studying them. Then follow several chapters on the relation of plants to their environment, their cellular structure, the manufacture of food, the movement of materials, and the energy relations. Seven chapters are devoted to the properties of

stems. The different types are described and a study made of the external features of stems in relation to their development. The part on structure deals briefly with the different tissues and points out the distinguishing features of monocot, dicot, and coniferous stems. Then follows a consideration of growth, the movement of materials, and a description of ecological types.

To introduce the factors which affect growth and reproduction the author uses the effect of relative length of day and night. The recent work on this subject is described and well illustrated. The chemical elements necessary for growth, the effect of temperature, soil acidity, soil structure, and moisture conditions are taken up in order. The matter of reproduction is naturally divided into vegetative and sexual. The structure of the flower is brough in at this point. The development of the egg cell and the process of fertilization are illustrated by photo-micrographs and it must be admitted that for the beginner at least, drawings would have shown the essential points much more clearly.

Three chapters are given to the subject of genetics. The objects of plant breeding are outlined in relation to increased yield and the production of new varieties. To illustrate the inheritance of characters use is made of Mendel's experiments with peas. The results in the first and second generation of a monohybrid and of a dihybrid cross are carefully described and diagramed. Sufficient description and illustration of cell structure is given to enable the student to understand the cytological basis for the behavior of characters in heredity. One chapter is given to mutations and variations. Although the space available for this subject in a book of this kind is necessarily small, the author has given a very clear and concise treatment sufficient to emphasize the importance of heredity.

The various types of vegetation found in different parts of the country make it important to give a general idea of plant distribution. The author has discussed the vegetation of North America and the relation of plant industries to climatic plant formations. Relatively little space is given to the plant groups as such. The life history of a few representatives of the algae, bryophytes, pteridophytes, gymnosperms, and angiosperms are described. The angiosperms are given more space than the other groups and some of the economically important and peculiar families are described. To make the book complete, two short chapters are devoted to fossil forms and the subject of evolution.

The not often met with inclusion of references at the end of the chapters in a book of this kind is a point to be commended. In spite of the fact that probably few beginners make use of such references, it adds to the value of the text to have at least a few of the more general ones included.

Dr. Transeau is to be congratulated on having made available such a useful text. The arrangement is pedagogically correct, the material botanically sound, and the whole book remarkably free from typographical errors.

H. C. M.

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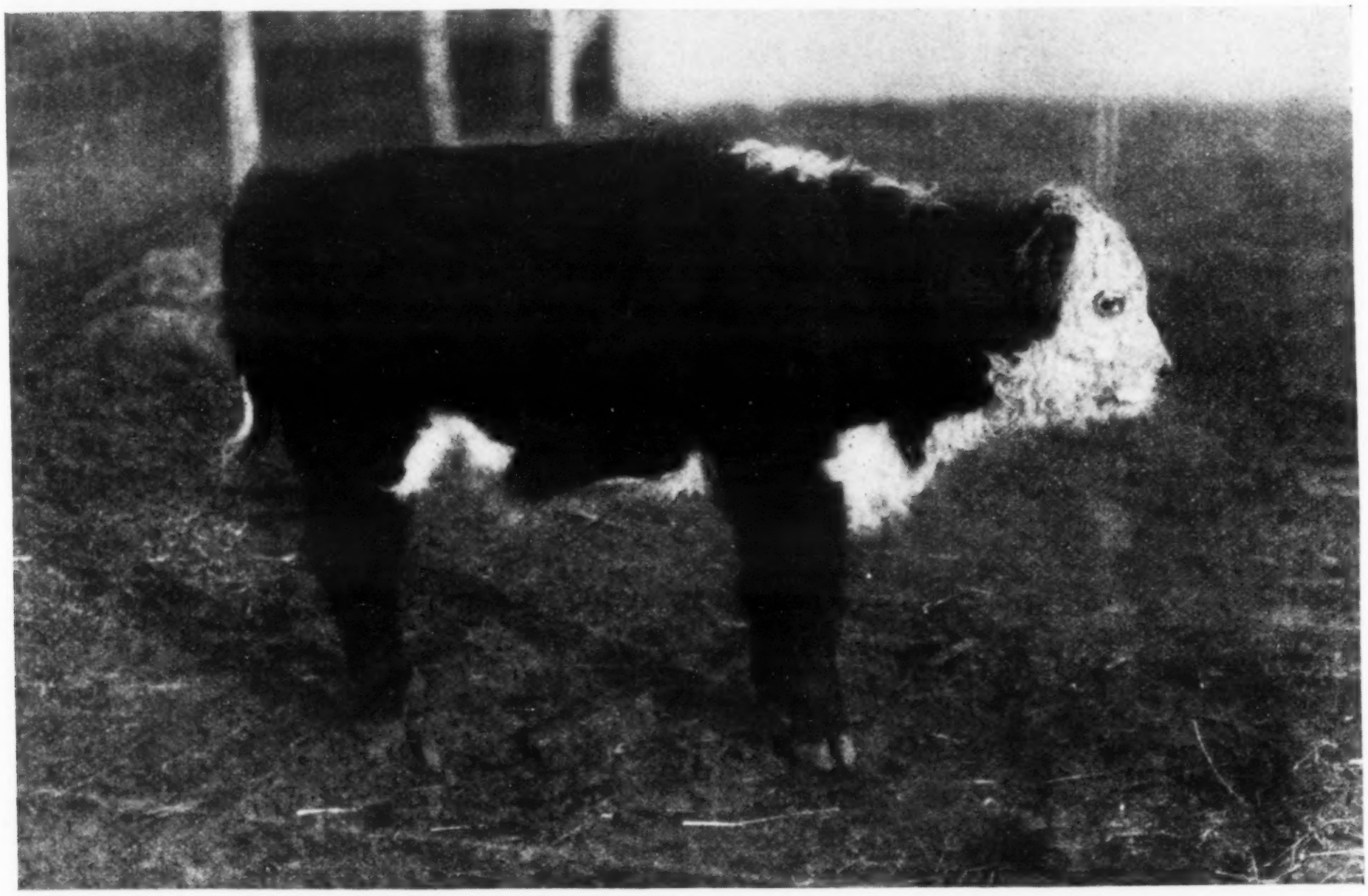
THYROID INFLUENCE IN CATTLE

W. A. Craft and H. W. Orr

Oklahoma Agricultural College and Experimental Station, Stillwater, Oklahoma.



A CRETIN CALF

Figure 11. The tryroid and pituitary glands were found to be much underdeveloped, which undoubtedly accounts for the abnormality. Several years ago a herd of cattle was reported in which one-fourth of the animals were "bulldog cattle" with deficient thyroid glands. In this herd the defect appeared to be inherited in Mendelian fashion.

IN NOVEMBER 1923 an abnormal, undersized steer calf came to the attention of the writers. The symptoms exhibited by the calf were similar to those observed in cases of cretinism in man; a general dwarf-like condition, short and irregularly curved legs, abnormally large joints, short and thickened face, and a nervous disposition. The calf was not subjected to experimental treatment, but was kept under close observation until the latter part of January, 1924. During this time it received the best of feed and care. Although allowed the same feed mixtures as the show cattle at the Oklahoma A. and M. College, it showed only a slight improvement during the time it was under observation.

This calf was dropped on the ranch of Mr. E. P. Lowery, Loco, Oklahoma, in March, 1923. (The exact date of birth is unknown.) It exhibited an abnormal appearance at birth and did not show any marked changes later on, according to Mr. Lowery. The calf was sired by a purebred Hereford bull, out of a good grade Hereford cow.

It was slaughtered January 23, 1924, at which time it weighed 330 pounds. A careful examination was made of the thyroid, parathyroids, and the pitui-

tary body, which revealed that these glands were markedly undeveloped. We were unable to determine whether the condition was due to degeneration or a failure of development. The thyroid proved to be only about one-fifth the normal size, and the parathyroids were correspondingly small. The pituitary body showed about fifty per cent normal development. No abnormalities were observed in the other glands or in any part of the viscera. In general, the bone lacked the firmness characteristic of normal bone. The ends of all the long bones were somewhat enlarged, and the bones were irregularly curved.

The condition of the glands observed in this case leads us to believe that the abnormalities found in the calf were probably due to a deficiency in the secretions of the thyroid and pituitary body.

Although very little is positively known about the influence of the thyroid and the pituitary body in cattle, it is probably true that these glands are associated with development of the individual in the same manner as they are known to be associated with development in man. Hammett[1] states that it is possible to show that thyroid activity is a factor of great importance in quantitative differential development. Possibly the thyroid may have a specific function in qualitative development also, but at present there is no evidence available which would justify the claim of any definite influence of the gland on this phase of growth.

Cretins have been reported in Dexter Kerry cattle by Seligman[2]. The most striking features of these animals are very short legs and short trunk, very much rounded head, with the forehead bulging over the nose and upper jaw, but with the lower jaw normally developed, giving these creatures a bull-dog appearance. The abdominal walls were always incomplete, with the viscera protruding through the gap. The thyroid was irregularly developed and small. Apparently the secretion of the gland was not normal as injections of the gland into other animals did not produce characteristic effects. Cretinism was associated with placental disease, but whether this was the cause of the cretinism was not clear.

It is known that two types of defective children result from thyroid deficiency. The first[3] is due to the absence of the gland and the second to a failure of the thyroid to develop normally, which may be of varying degree. In either case the individual shows a lack of development which seems to vary to some extent. The condition associated with thyroid deficiency in children is termed cretinism, and is characterized by the failure of growth, bowed limbs, pendulous abdomen, dry skin, thickened lips and lolling tongue. Smith states that in most animals much the same results are obtained when the thyroid is removed, but when the parathyroids are excised, death rapidly ensues, preceded by convulsions. The removal of the thyroid gives rise to a train of symptoms accompanied by chronic wasting and malnutrition, which make their appearance much more slowly than those produced by the excision of the parathyroids. It appears that the thyroid is associated in some way with calcium metabolism, and that the parathyroids are connected with the activity of the central nervous system. Smith further states that the pituitary body plays an important but little understood part in controlling the growth and development of the skeleton. In our observations of this case, we were unable to detect any disproportionate development of either lobe of the pituitary.

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INHERITANCE OF "BOLTING" IN CABBAGE

"Tendency to Bolt" Probably a Recessive Mendelian Character

E. P. Foquett Sutton

Royal Seed Establishment, Reading, England.

IN England, varieties of Garden Cabbages are generally divided into two groups:

(a) those which are suitable for sowing in spring only, and

(b) those which can be sown in both spring and in July or early August.

It is a curious fact that whilst all varieties of cabbage (*Brassica oleracea capitata*) when sown in the spring, will, under suitable conditions of cultivation, produce good solid heads in the succeeding summer and autumn, only a few of them are also suited for sowing in July and early August to head up during the following spring.

Those varieties which are not suited for sowing in July and August will, if sown at that time, produce flower stems in the spring instead of making heads, and are consequently worthless from a culinary point of view. As the sowing of cabbage seeds in July and August to produce heads during the following spring and early summer is much practiced in England, it is of the utmost importance to the grower that he should sow only a strain of seed which has been selected and developed for this "non-bolting" character, as otherwise he may in the spring find himself with a field of plants all run to flower instead of a crop of marketable solid heads of cabbage.

The usual method of cultivating these so-called "spring" cabbages in England is to sow the seed at the end of July or early in August, and transplant to the field about the beginning of October. The plants will then usually go through the winters experienced here without protection, and, according to the earliness of the variety, will commence to make solid heads from about April onwards.

How this "non-bolting" tendency was first discovered, it is practically impossible to say, but generations of seed growers have taken advantage of this fact to select plants with a tendency to produce hearts instead of "bolting," until strains have been evolved which in a normal season show little tendency to run to seed. There is, however, always a tendency for a small percentage of plants to "bolt" even in the most carefully selected stocks, if the seed is sown too early in July, or in mild seasons, which allow of too great a development of the plants before winter sets in. On the other hand, some of those varieties which are only considered of value for spring sowing, will in favourable seasons produce a small percentage of solid heads when sown in July or August, though they usually head up later and the crop is correspondingly of less value.

Whilst, therefore, not regarding "bolting" itself as a fixed character, many years of observation here have led me to look upon the "tendency to bolt" as a possible definite Mendelian "recessive." Experiments have been made with crosses between "bolting" and "non-bolting" strains, and in normal seasons all the first generation plants have hearted up and showed no trace of the "bolting" tendency. Unfortunately owing to the intervention of the war, and the great difficulty of getting the hybrid plants to produce seed under control, very few of the crosses have been carried on to the second generation. It is possible, however, to give one interesting case, and

PARENTAL TYPES IN CABBAGE CROSS

FIGURE 12. Above is shown the female parent, a green "hearting" variety—that is, one that can be sown in July or early August to produce heads the following spring, instead of going to seed. The male parent (below) is a red "bolting" variety, in which the plants do go to seed in the spring when raised in this way. The first generation plants of this cross were all dilute red in color, and did not "bolt."

27 Red "Hearting"

10 Green "Hearting"

8 Red "Bolting"

3 Green "Bolting"

SECOND GENERATION OF CROSS

FIGURE 13. Although the number of second generation plants raised was small, it points to a 9:3:3:1 ratio, expected in crosses involving two independent pairs of Mendelian factors. Bolting itself can hardly be regarded as a fixed character, but the *tendency* to bolt appears to be inherited definitely, with its expression considerably influenced by seasonal weather conditions and early sowing. The inheritance of "bolting" is of considerable importance to English market growers, who sow much cabbage in the late summer and winter it in the field without protection, to make an early crop the following spring. Naturally, a field of "bolting" cabbage is of small value to them.

although the number of plants raised in the second generation was limited, too limited, in fact, to draw very definite conclusions, it was sufficient to point to the probability of the truth of my hypothesis.

For example, the Red Pickling Cabbage possesses the "bolting" tendency to a very great extent when sown in July or August, and an experiment was made by crossing together a red "bolter" and a good "non-bolting" strain of green-heading cabbage, thus combining two pairs of factors, "bolting" and "non-bolting" tendency, and "red" and "green" colour. To avoid complications, other factors such as shape of heart, etc., were purposely ignored.

Figure 12 shows the female or seed bearing parent (Green heading), and a normal heading plant of Red Cabbage, a "bolting" plant, which was used as the pollen parent.

The first generation plants were not photographed, but they all formed hearts, and were all red in colour, though as was to be expected, the shade of red was more dilute.

One of these plants was seeded under control, free from any danger of natural cross-fertilization, and the few seeds which were harvested were sown early in August, 1922.

In the spring of 1923 the following results were obtained:

Twenty-seven plants, red in colour (red colour varying) and all plants "hearting."
Ten plants, red in colour, all plants "bolting."
Eight plants, green in colour, all plants "hearting."
Three plants, green in colour, all plants "bolting."

(Plants of these four types are shown in Figure 13.)

This experiment was not carried out so much from a scientific point of view as from that of the practical seed grower, so that these facts and figures are placed before the reader to enable him to theorize to his own satisfaction. There is, however, an undoubted pointer here to the 9:3:3:1 ratio.

It must, of course, be understood that the term "non-bolting" is only a comparative one and applies to strains or varieties only when sown and cultivated within certain periods.

For example, a strain of "non-bolting" cabbage may in a normal season be perfectly free from any tendency to bolt if sown not earlier than the end of July, but the same seed sown a month earlier would probably allow the plants to make so much growth before the winter that all would "bolt" in the spring, and thus follow their natural biennial tendency to produce seed the year following the sowing. A "non-bolting" type, however, sown at the end of July would make heads the following spring, but these would not run to seed until the year following, that is, the third year.

There seems to be a great probability that the "bolting" tendency in some other plants, such as Beetroot, Mangold, Onion, and Spinach, may be of a like nature, and if so it may be possible in the future to raise strains by single line selection which will enable some of these subjects to be sown considerably earlier than usual without the fear of a large number of them prematurely bolting to seed as annuals.

Already Professor Bateson of the John Innes Institution has evolved a strain of Sutton's Golden Tankard Mangold, in which the tendency for some plants to "bolt" when sown extra early, has been practically eliminated.

This strain is being put into commerce by my house this season and should prove of the highest possible value to farmers where climatic conditions demand somewhat early sowing of this valuable root for cattle feeding.

SELECTING FARM ANIMALS

By a New Method

B. M. GONZALEZ[1]

College of Agriculture, University of the Philippines

DISPOSING of the surplus animals which accumulate in the course of his operations is a constant problem with the animal breeder. He must get rid of the animals for three principal reasons: (1) to obtain income; (2) to reduce the size of the herd suitable to the size of the farm; and (3) to improve the quality of the herd.

Every breeder has to face this situation in one way or another and a great deal of his success depends on how he meets it.

It is common knowledge in the Philippines that when one desires good animals, the old large ranches are the last place to go to. There are several reasons for this, which I cannot take up at present, but not least among them is the fact that when a buyer comes to one of these ranches he is taken to the herd and allowed to pick out the animals he likes. If he knows his business he naturally picks the best ones. Obviously the continued repetition of this process leaves nothing but the scrubs and culls to perpetuate the herd.

The stockman's usual method of selection is to look over the animal as to size, conformation, age, quality, etc. The sum total of the impressions left in his mind is his final judgment of the animal. This process, not being scientific, requires a great deal of acumen, experience, and natural ability on the part of the judge.

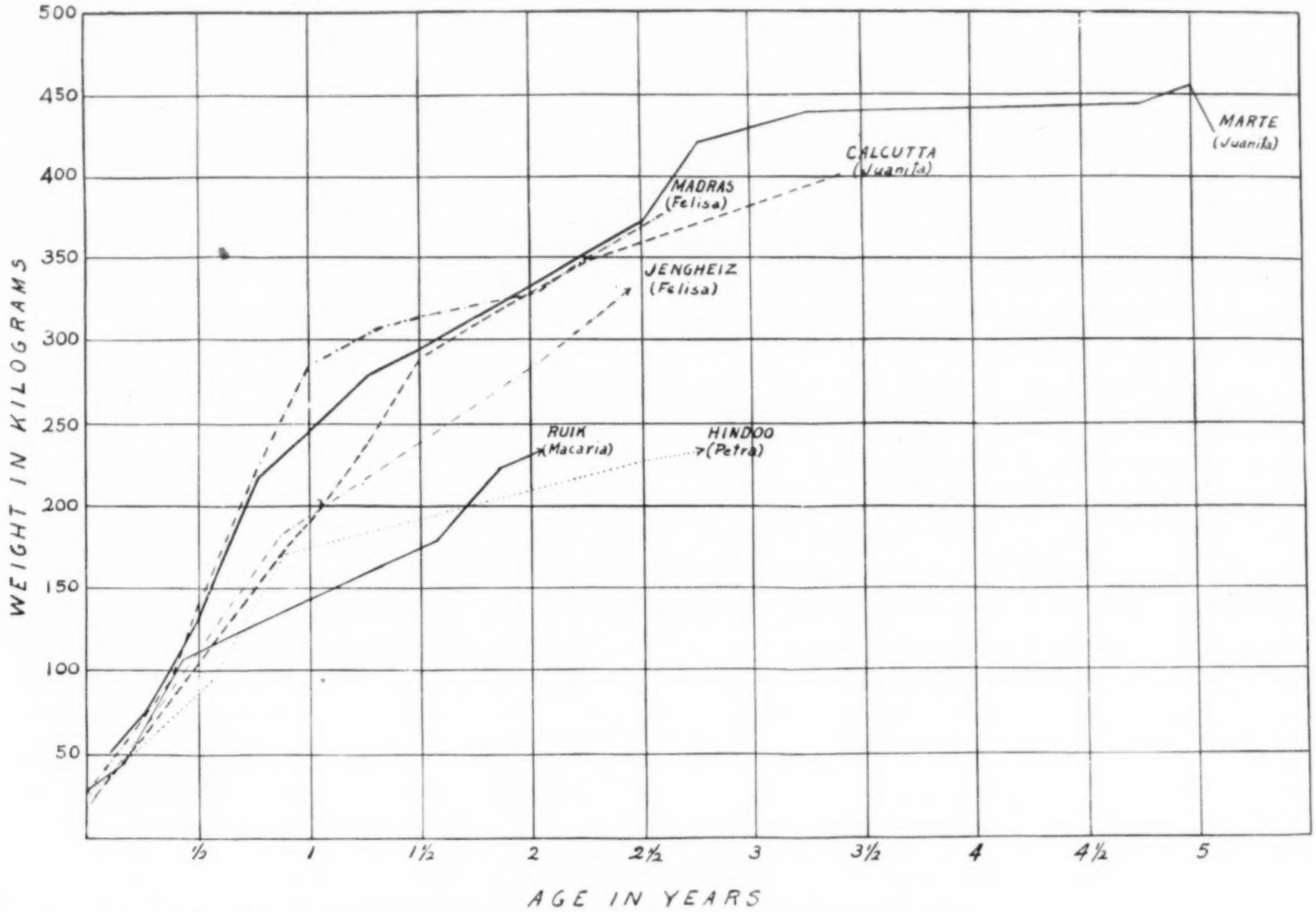
It is the object of this paper to describe a scientific method which will serve as a supplement to the intuition of the born judge of animals. Being scientific, it is accurate and it is easy to follow; a young stockman may put it into practice and achieve with it a degree of success that is fairly comparable to that of the consummate judge. The method is neither exclusive nor of universal application. It is not intended to supplant the judge in the show ring, nor milk records, but it is rather for the individual stockman, to utilize in his efforts to keep the best animals in his herd, and to supplement the usual procedure.

The method rests on these fundamental assumptions: (1) Other conditions being equal, the larger animal is the more desirable; (2) the animal that attains its full size in the briefest period is to be preferred to a slower growing animal.

The weight of all animals in the herd is recorded at birth and at more or less regular intervals thereafter, so that an accurate record is obtained of the development of each animal. In this College we weigh all animals about the first day of every month. Weighings every three months, or even every six months, are fairly satisfactory, if it is not practicable to weigh oftener. Then when one desires to compare two or more animals for a positive or negative selection; to select a herd sire, for example, or to sell out or castrate undesirable bulls, all one needs to do is to compare the records of the animals under consideration. Then the final choice may be made by actual examination of the animals showing the best records, or poorest records, as the case may be.

A concrete case was presented to us in the Animal Husbandry Department. We had a number of Indian-Nellore (Zebu) bulls. We had no use and no room for all of them. Naturally, we wanted to know which was the best to

[1]Paper read January 29, 1924, before the Los Banos Biological Club.



GROWTH CURVES OF ZEBU BULLS

FIGURE 14. Graph showing growth of Nellore (Zebu) bulls at College of Agriculture up to January 1, 1924. The names in parentheses are those of the dams.

keep and which we should dispose of. We plotted the information we had of the animals and the result is shown in Figure 14.

This made the preliminary decision a fairly easy matter, and the choice was narrowed down to three animals. Calcutta was sold because he had a very poor conformation. As Madras had been loaned we were unable to complete his record. Marte is heading the herd at present. We have recalled Madras and when he comes in it will be possible to settle definitely which animal will be the final choice for our herd bull.

You will notice that through this method the animals are reduced to a common age basis enabling one to compare young animals with older ones; a son with his father, for example. This method makes it possible for us to compare the results of our selection work, say ten or twenty years hence, with the record of our original animals. This comparison would be impossible with ordinary judging.

While climate, food supply and other features of the environment are more or less variable, yet the sum total of their effects on the individual animal in the course of three to five years of its life will tend to be fairly uniform. Should it be found desirable to consider radical changes in the environment, still it will be possible by this method to pick out the best animal under the conditions.

Rather incidental, though important, is the fact that a graph prepared from records, such as described above, points quite unmistakably to certain individuals as the sources of superior animals. In the graph, for example, one may notice that the calves of the cow Juanita rank among the best.

The method, in spite of its limitations, marks a step forward in our efforts to use more exact methods in the study of live stock.

PISTILLODY IN WHEAT FLOWERS

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Bureau of Plant Industry, Washington, D. C.

THE reproductive organs of a wheat flower consist normally of a carpel, or simple pistil, surrounded by three stamens. The carpel is made up of a single ovary containing one ovule and bearing at the top two filiform, erect, smooth styles (axes) which bear from the base to the tip numerous, divergent, simple, hair-like branches which are papillate and stigmatic (Figure 15, *D*). These branches are referred to hereafter as stigma hairs. The stamens have distinct filaments, which are very short in the closed flower but which elongate rapidly at the time of flowering, thereby elevating the linear-oblong anthers to which they are attached.

Each wheat flower is inclosed by an outer glume, called the lemma, and an inner glume, called the palea. Three to five such flowers, attached alternately to opposite sides of a central axis or rachilla and subtended by two empty scales, called the glumes, make up the spikelet. The spikelets are borne single on alternate sides at the articulations of a flattened, zigzag rachis. The entire inflorescence, made up usually of from 15 to 25 such spikelets, is called the spike or head.

The wheat flower is extremely stable, very few abnormalities ever having been reported. Malformations are of common occurrence in the plant kingdom, however, such phenomena usually being marked by partial or complete transformation in the configuration of organs and by associated changes in their functions.

An example involving partial transformation of a wheat anther into a process bearing stigma hairs was reported by Anthony[1].*

In the modified stamen observed by him the filament united with the affected part and formed practically one body.

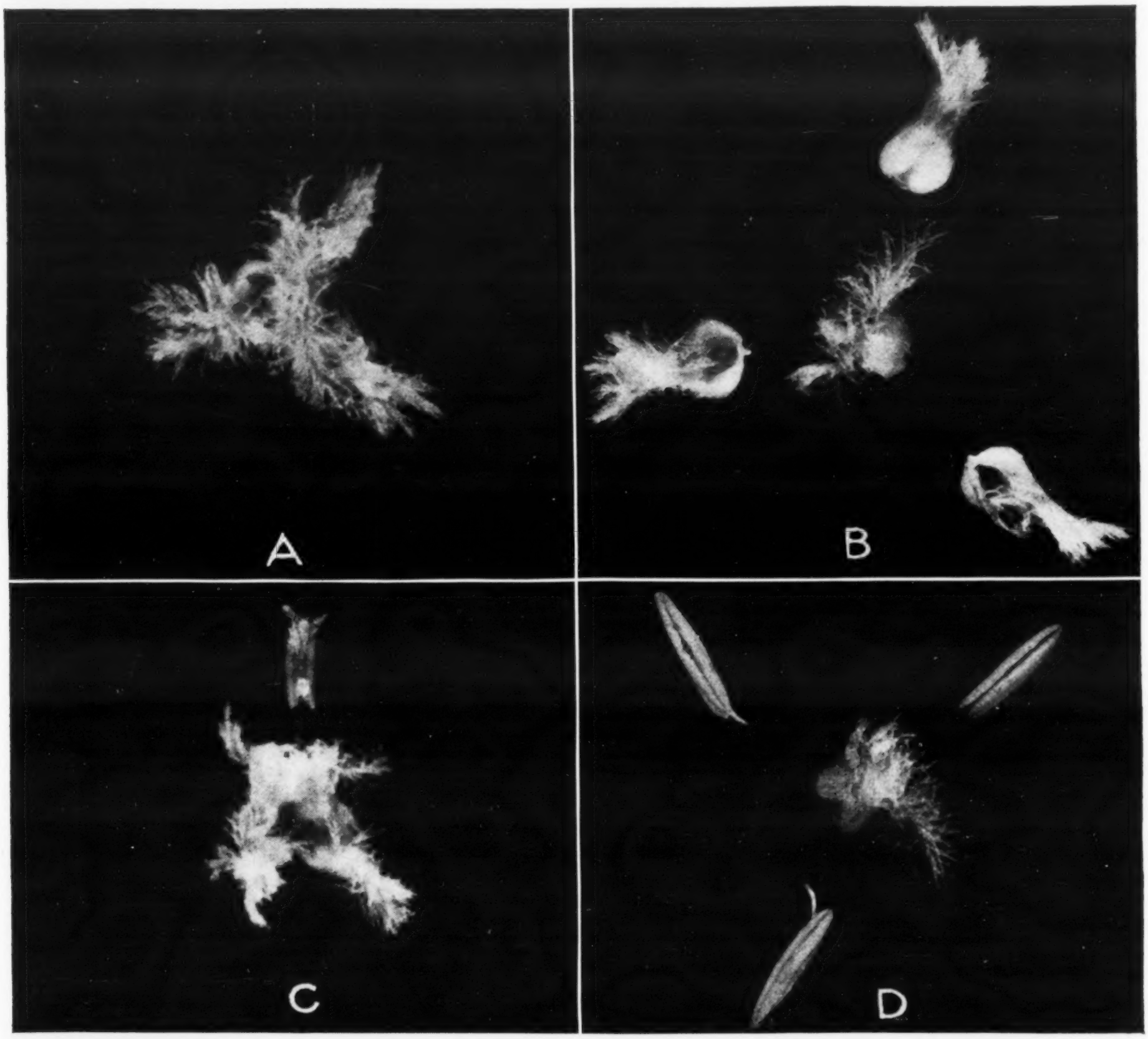
Abnormalities Observed

In the spring of 1923, numerous abnormal flowers were observed in several plants of a variety of common wheat (*Triticum vulgare* Vill.) growing in the greenhouse of the United States Department of Agriculture at Arlington Experiment Farm, Rosslyn, Virginia. The seed from which these plants were produced was received from Argentina in 1922, and was planted in the fall of that year in a bed in the greenhouse where the temperature was maintained between 50 to 60 degrees F. during the entire growing period of the plants.

The malformations coming under the notice of the writers involved a transformation of stamens either into carpels, or into structures which were partly stamens and partly carpels (Figure 15). Considerable variation existed in the degree of transformation in different flowers. In some cases only one stamen was affected, in others two, and at times all three of the stamens were either partially or completely metamorphosed into carpels. Completely transformed stamens are hereafter referred to as "extra carpels."

The extra carpels occupied the same position in a wheat flower as the stamens which they replaced. In structure they were much like the central or normal carpel but could be readily distinguished from the latter by a concave, furrowless area on the side next to the central carpel. In most cases they bore only a single style (axis) with its tuft of stigma hairs, but in

*For numbered references, see *Literature Cited* at end of article.

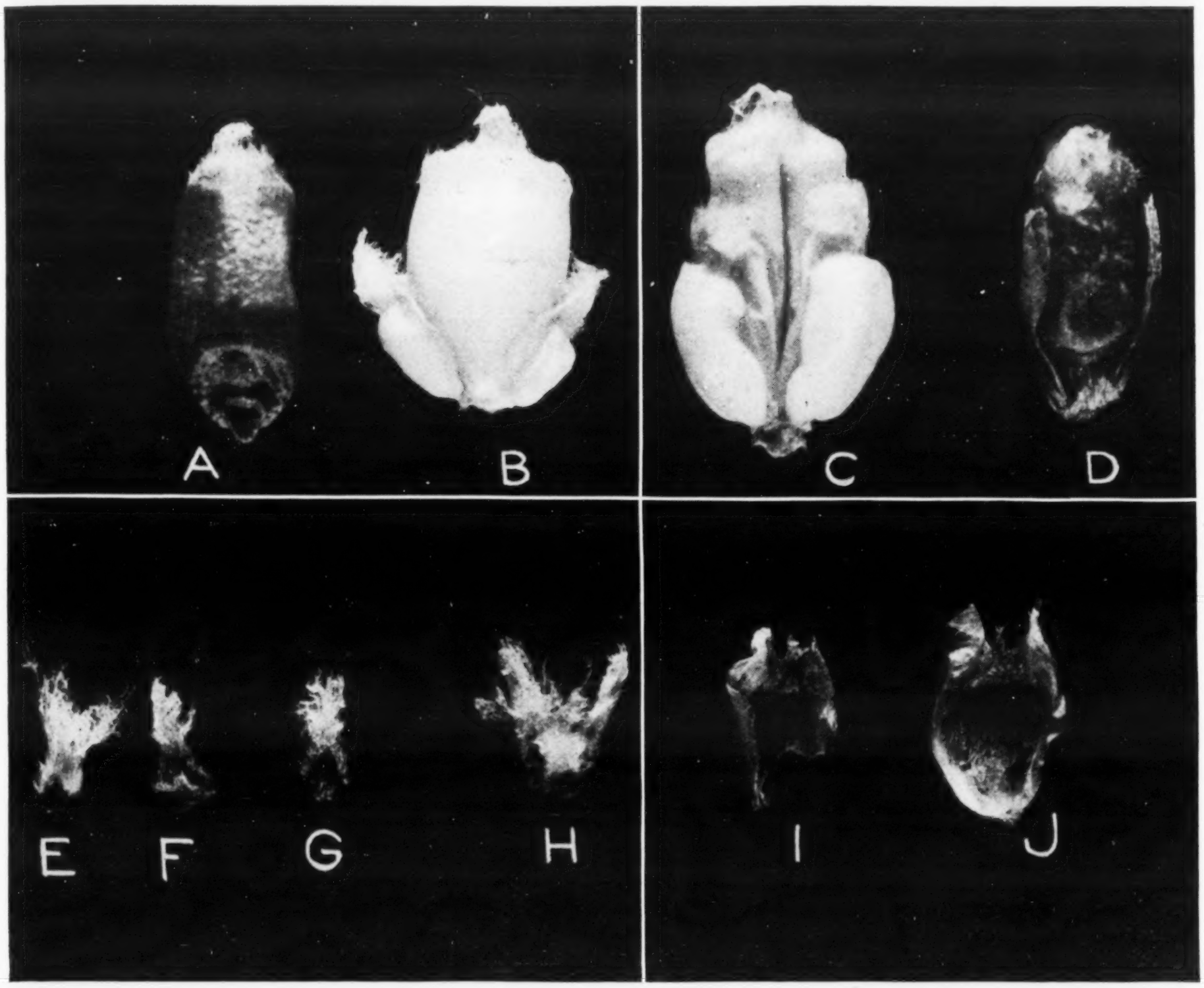


METAMORPHOSED AND NORMAL STAMENS IN WHEAT FLOWERS

FIGURE 15. *A*—Reproductive organs of a malformed wheat flower in which all the stamens are converted into carpels. *B*—The same flower shown at *A*, but with the "extra carpels" separated to show the transformation of stamens into carpels. *C*—A flower in which two stamens were converted into carpels while the remaining stamen exhibited only partial metamorphosis. *D*—A normal wheat flower, showing the carpel and three stamens separated. The causes of such abnormalities are not known. It has been suggested that the growth of the flower parts is controlled by definite chemical substances formed in the leaves, similar to the hormones that have recently taken such an important place in animal physiology. Variations in the time of formation of "hormones" would produce such abnormalities.

some cases two styles (axes) with stigma hairs were present. The completely transformed carpels bore no resemblance to stamens. Their ovaries did not appear to be modified filaments nor their stigmas modified anthers (Figure 15, *B*). Except for their occupying the normal position of stamens in the flower these extra carpels would seem to have no relation to the stamens. The partially transformed stamens, on the other hand, had normal filaments and anthers much like the normal, except that they bore stigma hairs (Figure 15, *C*).

In addition to differences in the degree of transformation in different flowers, the percentage of the flowers in which abnormalities occurred varied in the several heads concerned. In Table I data are given for ten heads from as many plants on the number of



KERNELS AND CARPELS FROM MALFORMED WHEAT FLOWERS

FIGURE 16. *A*—A normal mature seed obtained from a flower all of the stamens of which were transformed into carpels. *B, C*—Immature kernels of wheat showing ovaries of extra carpels and their relative size as compared with the central ovary. *D*—A mature kernel, showing shrivelled ovaries of extra carpels of a malformed flower. *E*—Unfertilized central carpel of a malformed flower. *F, G*—Extra carpels from the same flower producing *E*, showing the comparative size of the two kinds of carpels when fertilization has not been effected. *H*—All unfertilized carpels of a malformed flower intact. *I, J*—Individual scale-like remains of extra carpels developed upon fertilization of the central carpel of a malformed flower.

flowers in which all three stamens, two stamens, one stamen and no stamens were metamorphosed into carpels. Nearly all of the abnormalities occurred in the two lowest flowers of the spikelets. In a total of 500 flowers examined on these heads 249, or 49.8 per cent, were more or less abnormal. Of these abnormal flowers 240 were in the two lowest positions in spikelets, while only 9 were among the upper flowers of the spikelets. In the ten heads there were 314 flowers in the two lowest positions in the spikelets, of which 74 were normal. Of 186 flowers above the lowest two in the spikelets, 177 were normal.

Whenever two stamens of a flower were metamorphosed into carpels, the third stamen frequently exhibited partial metamorphosis, as shown in Figure 15, *C*. Some stamens were found in which the anthers had developed only a few stigma hairs, while others exhibited hairs in abundance. These partially transformed anthers are similar to those described by Anthony (*loc. cit.*), but the abnormal flowers observed by him did not have any stamen completely changed to a carpel.

The flowers having all of the stamens completely metamorphosed usually produced no seed, such failure being attributed to the absence of pollen-producing organs in these flowers. In several instances, however, a single seed was obtained from such flowers, fertilization doubtless having been effected by pollen from near-by normal flowers, possibly from the upper flowers in the same spikelet.

Whenever seed was obtained from any of the flowers containing extra carpels, it was the central carpel which produced it. No seed was obtained from any of the extra carpels, although attempts were made to produce seed by artificially pollinating the stigmas of the extra carpels.

When fertilization was not effected in a flower containing extra carpels, no growth took place either in the ovarial portion of the central carpel or in that of the extra carpels. When fertilization was effected, however, the ovarial portion of the central carpel of a malformed flower developed into a mature kernel. The ovaries of the extra carpels of such flowers, in several cases observed, also increased in size quite noticeably, but no kernel ever developed from them. Such a central carpel with adjacent extra carpels that have made considerable growth is shown in Figure 16, *C*. In this stage of development the extra ovaries rarely exceeded three-fourths the length of the central ovary. As no extra carpels have been found in which an embryo appeared to be developed, the increase in size of their ovaries may be due merely to a simulus received from the central ovary and not to separate fertilization. Starch grains have been found in these extra carpels, however.

This possibility is supported by the fact that no cases were observed in which the ovaries of extra carpels had increased in size without development of the ovary of the central carpel (Figure 16, *E* to *H*). This apparent functional deficiency indicates that the metamorphosis of a stamen into a carpel is incomplete.

In the mature stage of development the extra carpels appear only as mere scale-like appendages to the kernel developed from the central carpel (Fig. 16, *D*, *I*, and *J*). This may indicate that the contents of the extra ovaries have been absorbed by the developing central ovary, or that their growth did not proceed to the stage where storage materials were deposited in them. Seeds produced from the central carpels of malformed flowers, although somewhat misshapen, appear perfectly normal and germinate exactly as do seeds from normal flowers and the resulting seedlings make a normal growth.

The abnormal condition of the flowers described above did not reappear in 1924 in eighteen plants grown from seed produced by the plants showing these abnormalities. These plants, although grown in both pots and beds under practically the same greenhouse conditions as in the previous year, produced only normal flowers. It appears, therefore, that this abnormality of wheat flowers is not hereditary, but is due to some unknown, environmental cause operative in 1923 but not in 1924. It may be related in some way with the changed environment resulting from the introduction of the seed from Argentina, although plants from other lots of seed, introduced at the same time, did not exhibit these abnormalities.

Additional Observations

In the spring of 1924, additional observations of partially metamorphosed anthers were made in the greenhouse at Arlington Experiment Farm. Mr. J. W. Taylor found anthers of this kind, similar to those described by Anthony (*loc. cit.*), in three wheat-like plants of a nearly sterile strain of wheat and rye parentage. These plants, grown in fertile soil in a greenhouse bed, were developed from seed produced by plants which in turn had developed from seed produced by backcrossing a wheat-rye hybrid (F_1) with wheat pollen. In one of these plants all of the anthers on the principal

culms of the plant were partially metamorphosed, stigma hairs being present at the anther tips. About half of the anthers were affected in the second plant, while only a few anthers bore stigma hairs in the third.

The writers also observed similarly modified anthers in a few heads of two wheat plants growing in pots in the same greenhouse in the spring of 1924. One plant was from a lot of wheat (C. I. 6810) obtained from China in 1922, and the other from a lot (C. I. 6838) obtained from Australia in the same year.

Discussion

The anomalies referred to above present phenomena similar to those found in phyllody. In the latter case, stamens are transformed into foliage leaves or petals, while in the case observed stamens are partially or completely converted into carpels.

Goebel[2] (p. 329) states that a stamen is a sporophyll which has arisen by the transformation of a primordium of a foliage leaf. Furthermore, the degree of transformation of a stamen depends upon the stage of development of the primordium at the moment when the impulse resulting in the transformation occurs and upon the strength of the impulse. Such being the case, it would appear that in the flowers observed by the writers the impulse resulting in complete transformation of stamens into carpels had its origin at a very early period in the development of the primordium of a stamen but, in the cases involving partial metamorphosis of a stamen into a carpel, the impulse arose at some later period. The exact nature of the factors which are responsible for the abnormalities in the reproductive organs observed by the writers and their modus operandi are at present but vaguely understood.

A theoretical explanation of malformations, however, which may find application to the anomalies observed is offered by Sachs ([3], p. 307; [4], p. 235-236), who suggests that the differentiation of plant organs is dependent upon specific substances (chemical combinations) formed in the leaves, possibly in very small quantity, and which are transported to the vegetative point. Malformations in flowers may be due to a hastening or delaying of such organ-forming substances or to a slight deviation from their normal path in the passage to the vegetative point of a flower, where the primordia of different organs are rapidly developed and

TABLE I.—*Numbers of flowers in the two lowest spikelets, and in all spikelets above these, in 10 wheat spikes, having 3 stamens, 2 stamens, 1 stamen, and no stamen, metamorphosed into carpels.*

Head number	Numbers of flowers, in lower and upper positions in the spikelet, showing metamorphosis of 3, 2, 1, or 0 stamens								Total number of flowers	Percentage of abnormal flowers
	Two lowest flowers of spikelets				All flowers above lowest two					
	3	2	1	0	3	2	1	0		
1	16	9	3	5	0	0	0	18	51	54.9
3	11	6	4	9	0	0	0	13	43	48.8
4	0	3	1	21	0	0	0	11	36	11.1
5	10	1	8	14	0	0	0	15	48	39.6
6	11	6	3	14	0	0	0	14	48	41.7
7	17	9	0	0	0	0	7	6	39	84.6
8	19	7	0	3	0	0	0	25	54	48.1
9	22	4	4	2	0	0	0	29	61	49.2
10	24	3	4	4	0	0	0	29	64	48.4
11	23	7	5	2	0	2	0	17	56	66.1
Totals	153	55	32	74	0	2	7	177	500	49.8

laid down at short intervals. Goebel (*loc. cit.*) suggests that hormones and changes taking place in the concentration of protoplasmic fluids may be responsible for such abnormalities.

Whatever the nature of the processes involved in the metamorphosis of one organ into another, the various transformations herein recorded serve to indicate the delicacy and precision of the operation of the internal mechanism of the plant.

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Evolution in the Georgia Legislature

The Lawmakers of Another State Take up the Question of Deciding What Their Constituents May Think

ATLANTA, Ga., July 31. — The Georgia House of Representatives had before it today a favorable report from its committee on education of a bill to withdraw all State funds from any school or other institution at which the Darwin theory or any other similar theory of evolution is taught. The bill is a copy of the Kentucky law.

Representative Pope styled the theory of evolution as "rotten stuff." Representative McCrory, speaking before the committee, said if he was descended from a monkey he was ashamed of it, but didn't think he was. He said he believed God created man and monkeys entirely separate, and he didn't believe "they had ever mixed and hoped they never would."

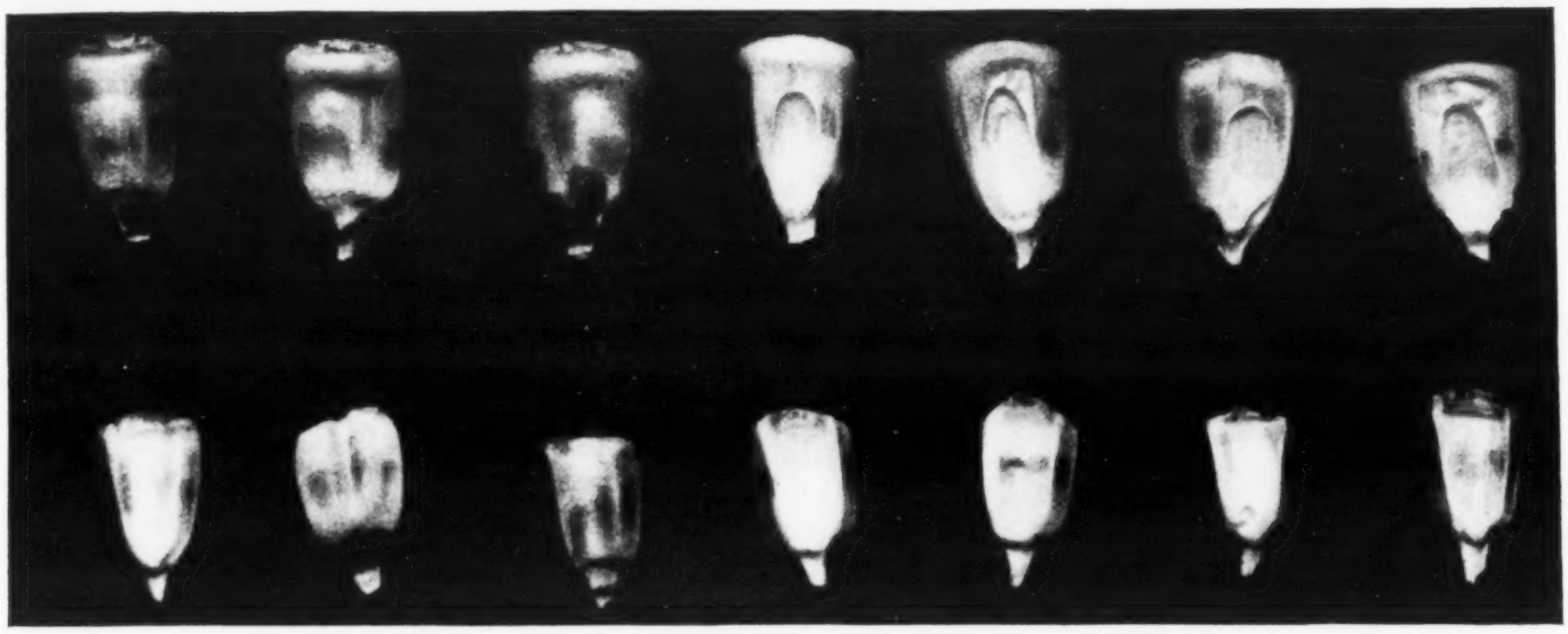
Representative Covington said "the only thing wrong with those two Chicago youths, Loeb and Leopold, is that they went to schools and colleges where they were taught pagan philosophy. If those old alienists told the truth they would tell that, too." He said he didn't believe a wagon load of mud could be left in the road and "by its own inherent evolutionary powers" become something "all dresed up and running for the legislature."

"Do you think it would have to evolute far?" asked Chairman Elders. Judge Covington did not reply.—*Associated Press.*

HERITABLE CHARACTERS OF MAIZE

XVIII—Miniature Germ

JOHN B. WENTZ
Iowa State College, Ames, Iowa



NORMAL AND "MINIATURE GERM" KERNELS

FIGURE 17. The three left-hand kernels in each row show the abgerminal side, the remaining kernels the germinal side. The miniature germ kernels are in the lower row. Note that there is very little difference between the two sides of these. The tiny germ, no larger than that of a grain of wheat, can be seen best in the second kernel from the right.

IN THE winter and spring of 1923 a large number of selfed* ears of corn from several varieties and strains were examined for the germless character. Among the ears segregating for germless kernels there was found one ear from a yellow dent strain apparently bearing a type of germless kernel entirely different from the rest. The germless kernels in all the other ears had the same appearance as those reported by Demerec† in which the kernels are nearly of normal size, but with a characteristic sunken and wrinkled appearance of the germinal area, which has no distinct outline.

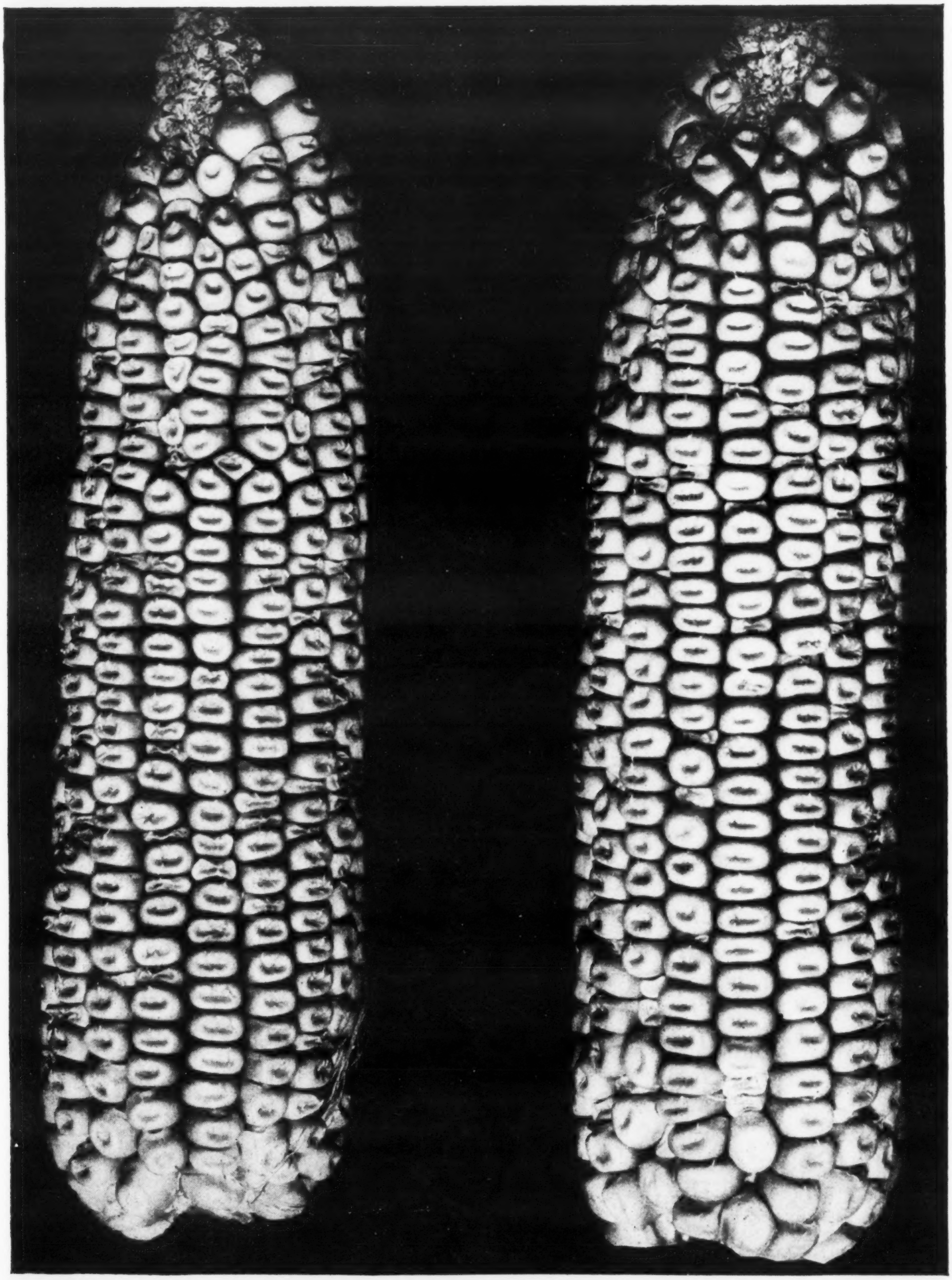
Description of Miniature Germ

In this new type, which has been given the name *miniature germ*, there seemed to be no germinal area at all, and in most of the kernels it was difficult to distinguish the germinal from the abgerminal side. Upon closer examination, however, it was found that most of these kernels had a very small embryo and many of them showed a very small germ area. This germ area was very close to the tip of the kernel, and, while it was only about the size of the germ on a good sized wheat kernel, it had a very distinct outline.

The germs were examined both in the dry condition and after soaking over night in water. In most of the kernels the embryos seemed to be normal excepting in size and shape. Besides being very small, they tended to be narrower and to extend deeper into the kernel in proportion to their size than normal seeds. Germination tests made on miniature germ kernels from the original ear and from several later segregating ears have shown germinating percentages ranging from four

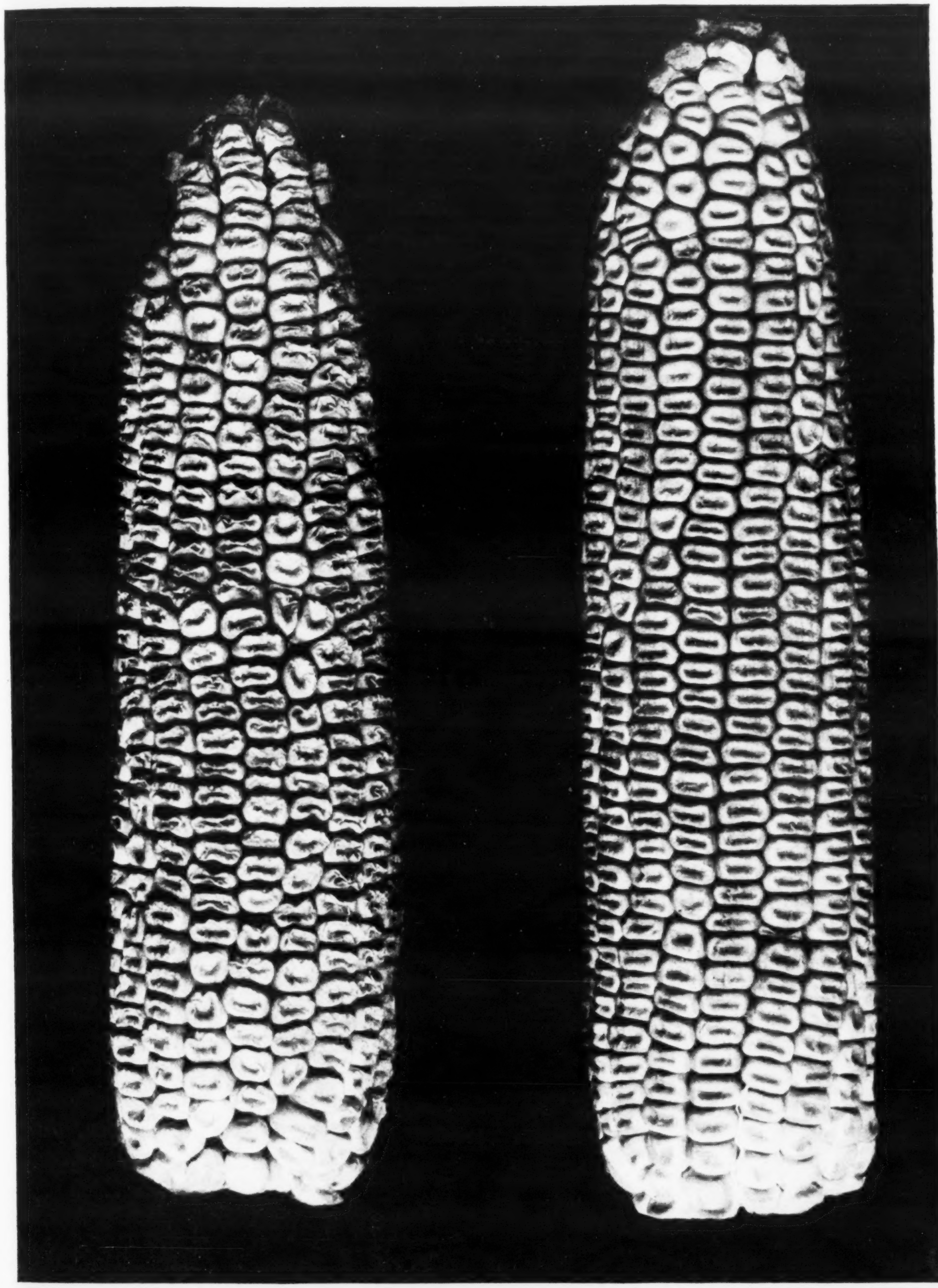
*Self-pollinated.

†DEMEREC, M. Heritable Characters of Maize. XV.—Germless Seeds. *Journal of Heredity*. 14:297-300. 1923.



EARS SEGREGATING FOR MINIATURE GERM

FIGURE 18. These self-pollinated ears have approximately three normal grains to one with miniature germ. The abnormal kernels can easily be identified, as they are shorter and smaller than the others. A fair proportion of the defective grains germinate, but the plants are so weak that they would hardly survive under field conditions.



"MINIATURE GERM" EARS

FIGURE 19. These are self-pollinated ears from plants grown from miniature germ kernels like those on the segregating ears of Figure 18. All the kernels on these ears have miniature germs. This is another of the injurious recessive characters, brought to light by inbreeding, that have been carried along indefinitely in the ordinary varieties of maize.

to thirty-six per cent. The most common percentages were from twelve to twenty.

Plants from the miniature germ kernels were weak at first and only a very small percentage of seeds planted in the field produced plants. But when kernels were planted about half an inch deep in the green-house in fine loam soil and kept moist by covering with a glass plate, the young plants had no difficulty in emerging. When planted in the field these plants developed normally and produced normal mature plants.

Inheritance of Miniature Germ

The original ear segregating for miniature germ showed a ratio of 443 normal (*Mg*) to 180 miniature germ (*mg*) kernels which was close enough to a 3:1 ratio to suggest the possibility of this character being inherited as a simple Mendelian factor.

In the spring of 1923 normal and miniature germ kernels from this original ear were planted in separate rows in the field. From the normal kernels forty-seven mature plants were obtained and from the miniature germ kernels five mature plants. Of the forty-seven plants from normal kernels twenty-two were self-pollinated. Of these twenty-two plants, seventeen gave segregating ears and five gave pure normal ears. This is a ratio of 17:5 as compared to a theoretical ratio of 14.66:7.33.

From the five plants coming from miniature germ kernels four selfed ears were obtained, three of which were pure for the miniature germ character while the fourth one showed segregation. The one segregating ear cannot be accounted for except that the kernel producing this plant might have been wrongly classified. The fact that too large a proportion of miniature germ kernels were found in the original ear from which these kernels came seems to bear this out.

The seventeen segregating ears were shelled and notes taken on the number of normal and miniature germ kernels on each ear. These data have been arranged in Table I. The data conform closely enough to the theoretical ratios so that there can be little doubt but that the miniature germ character is due to a single factor.

TABLE I.—*Showing progenies from normal kernels from the original self-pollinated ear segregating for normal and miniature germ kernels.*

Ear No.	Normal kernels	Miniature germ kernels	Total	Deviation from 3 : 1 ratio	P.E.	Deviation / P. E.
3	pure normal					
4	193	71	264	5.00	4.75	1.05
6	416	148	564	7.00	6.94	1.01
7	527	173	700	2.00	7.73	.25
8	182	71	253	7.75	4.65	1.66
14	pure normal					
17	147	59	206	7.50	4.19	1.78
18	345	129	474	10.50	6.36	1.65
19	328	100	428	7.00	6.04	1.16
20	368	110	478	9.50	6.39	1.49
23	296	112	408	10.00	5.90	1.69
24	455	156	611	3.25	7.22	.45
27	pure normal					
28	470	144	614	9.50	7.24	1.31
29	202	58	260	7.00	4.71	1.49
30	236	70	306	6.50	5.11	1.27
33	413	118	531	14.75	6.73	2.19
34	382	126	508	1.00	6.58	.15
36	425	143	568	1.00	6.96	.14
37	332	132	464	16.00	6.29	2.54
42	pure normal					
47	pure normal					
Total	5717	1920	7637	10.75	25.54	.42
Theoretical	5727.75	1909.25				